ABSTRACT

This paper will present a novel approach for developing electronics for controlling spacecraft/robotic vehicles. This approach is based on a distributed system using Philips Semiconductor's I^2C bus and what we call a Remote Engineering Unit (REU). We feel that this approach has significant advantages over the conventional centralized design previously developed for missions such as Mars Pathfinder Mission. This work was developed for Mars Surveyor Program (MSP) Athena Rover project, which is an integral part of the Mars Sample Return project planned for launch in 2003/2005.

To: Mary Sue 4-2842 CL-00-330 2pgs

Distributed Architecture for Controlling Spacecraft/Robotic Vehicles Using Remote Engineering Unit(REU)

TBD
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

Sung Park's abstract info

ABSTRACT

This paper will present the novel approach for developing electronics for controlling spacecraft/robotic vehicles. This approach is based on a distributed system using i2c bus and what we call a Remote Engineering Unit (REU). We feel that this approach has significant advantages over the conventional centralized design previously developed for missions such as Mars Pathfinder Mission. This work was developed for MSP '03/05 Athena Rover project which is an integral part of the Mars Sample Return project planned for launch in 2003/2005.

MSP '03/05 Athena Rover

Mission Goals

Athena Rover is a robotic vehicle that was developed as an integral part of the Sample Return Mission. The rover flies to Mars on the back of the lander and is deployed on Mars surface to traverse, take images, and acquire rock and soil samples in the on-board sample cache. The rover, then returns to the lander and performs required positioning to transfer the sample cache to the Mars Ascent Vehicle(MAV) which is launched from the lander to Mars orbit for final sample cache relay. The extended mission goal includes acquisition of images of MAV launch.

Requirement

Athena Rover requires the control and navigation(C&N) electronics subsystem to interface 12 cameras, 30 DC brushed motors, and the housekeeping sensors such as temperature and position sensors as well as navigation sensors that include rate sensors, accelerometers, etc. In addition, the electronics subsystem is also responsible for power switching of heaters, encoders, release devices, etc., and interface to the communication subsystem.

Implementation with REUs

The C&N electronics for Athena Rover was developed based on a distributed architecture using REUs. With this approach, the control interfaces to the required I/Os are localized by each REU, which then remotely communicates with the main processor on a low speed serial bus. This distributed architecture using REU is significantly more advantageous than the conventional centralized design used in Mars Pathfinder's Sojourner electronics. These advantages include 1) reduction in complexity of overall system configuration 2) modular characteristics of the system 3) reduction in design cycle 4) increase in testability and 5) increase in adaptability.

The application in Athena Rover's C&N electronics embodies the advantages gained by using REUs. Each REU was designed to control 2 DC brushed motors with closed-loop PID controller implemented in hardware, 4 discrete power switches (2 for heaters and 2 for release devices), 16 analog inputs, and 8 discrete inputs which would be contact switch inputs in this case.

The system overview as well as the REU design approach are presented in the following sections.

System Overview

Requirements

With the given mass and power constraints of ~2kg and < 15W, respectively, C&N electronics of Athena Rover needs a core computer with processing capability of 10-12 MIPS with a floating point unit. The required memory capacity is 128 kbytes of PROM for boot code, 4 Mbytes of EEPROM for data storage, 32 Mbytes of DRAM for code execution, and 64 Mbytes of non-volatile memory (flash) for solid state recorder. The ethernet interface with 19.2 kb RS-422 serial interface are also required for telecom and GSE. A real time clock, time stamp, and watchdog timer are also necessary for provision of the time during the mission period.

The C&N electronics needs to provide an interface for APS camera which has an on-chip A/D and digital serial interface. There are 7 pairs of APS cameras, and yet it only has to provide 2 parallel serial interfaces to ascertain acquisition of image data from at least 2 stereo cameras at a given time.

Besides, the C&N electronics need to provide the necessary control interface circuits to analog telemetry inputs, digital I/Os, DC brushed motors, inertia

ACKNOWLEDGEMENT

The work described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

REFERENCES

1. J. Waters, E. Kopf, K. Mehaffey, G. Bolotin, M. Bell, Athena Rover Control & Navigation Subsystem, Mars Surveyor Program '03/05, Jet Propulsion Laboratory
2. E. Kopf, APEX Motor Controller MC7/DC7, version 2f, Jet Propulsion Laboratory.
3. MSP'03/05 Athena Rover Control & Navigation Subsystem:

   http://robotics.jpl.nasa.gov/people/stone/msp01/cn.html.
4. J. Waters, H. Stone, R. Welch, J. Matijevic, A. Mishkin, *Control & Navigation Functional Requirement Document, Rev. B-Draft,* Athena Rover Office, Mars Sample Return Project, Jet Propulsion Laboratory.
5. S. Park, *Prototype REU FPGA Design Specifications,* Athena Rover Control & Navigation Subsystem Electronics, Jet Propulsion Laboratory.